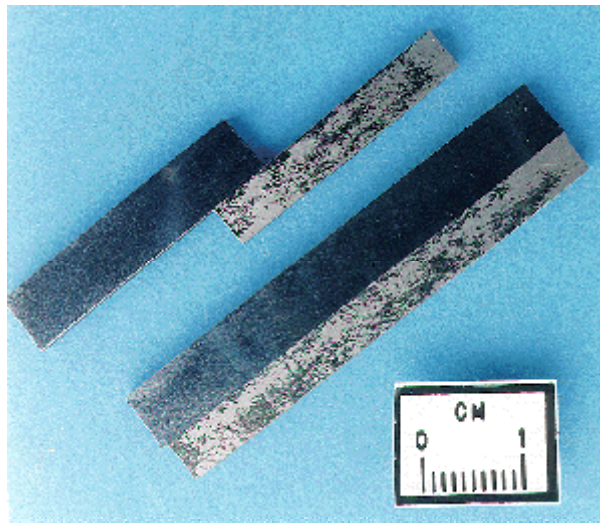


Rhenium Rocket Manufacturing Technology

The NASA Lewis Research Center's On-Board Propulsion Branch has a research and technology program to develop high-temperature (2200 °C), iridium-coated rhenium rocket chamber materials for radiation-cooled rockets in satellite propulsion systems. Although successful material demonstrations have gained much industry interest, acceptance of the technology has been hindered by a lack of demonstrated joining technologies and a sparse materials property data base.

To alleviate these concerns, we fabricated rhenium to C-103 alloy joints by three methods: explosive bonding, diffusion bonding, and brazing. The joints were tested by simulating their incorporation into a structure by welding and by simulating high-temperature operation. Test results show that the shear strength of the joints degrades with welding and elevated temperature operation but that it is adequate for the application. Rhenium is known to form brittle intermetallics with a number of elements, and this phenomena is suspected to cause the strength degradation. Further bonding tests with a tantalum diffusion barrier between the rhenium and C-103 is planned to prevent the formation of brittle intermetallics.



Rhenium bonded to C-103 by the explosive was evaluated and shown to have the necessary strength for the rocket application.

The rhenium material properties data needed by rocket designers was generated, and low-cycle fatigue tests of powder metallurgy (PM) rhenium specimens were successfully conducted. These specimens passed a 100-cycle test sequence indicating that powder metallurgy rhenium can meet the service requirements of small chemical rockets. Tensile properties of rhenium fabricated by chemical vapor deposition (CVD) and powder metallurgy were evaluated from room temperature to 1900 °C, and evaluations at 2200 °C are planned. These data indicate that either fabrication technique is viable. Rhenium creep tests also indicate that the material is suitable for use in rocket chambers at the pressures and elevated temperatures anticipated. Enhancement of the iridium oxidation resistance

also was demonstrated. A ceramic-oxide-coated, iridium-coated rhenium rocket chamber was successfully tested for 32 hr on gaseous hydrogen/gaseous oxygen propellants at a mixture ratio of 4. The oxidizer content in these gases is similar to that of Earth storables, indicating that the oxide coating causes a factor of 5 increase in life over previously tested iridium/rhenium chambers.

Under a Space Act Agreement, the NASA-developed rhenium rocket technology enabled TRW to develop an Advanced Dual Mode rocket with 328 sec of specific impulse. This engine will be baselined on the Lockheed Martin A2100 satellite, if it is flight qualified in the time frame required